



# Applications for Mission Operations Using Multi-Agent Model-Based Instructional Systems with Virtual Environments

**William J. Clancey, PhD**

**Chief Scientist, Human-Centered Computing**

**NASA Ames Research Center**

**& Institute for Human and Machine Cognition, UWF**

# Presentation Outline

---

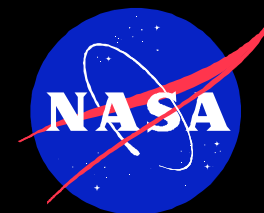
- **Intelligent Tutoring Systems —using AI (problem-solving models) for instruction**
- **Astronauts as Students**
- **ICAT: The Hubble Repair Training System**
- **Foundations for Revitalizing ITS at NASA**
  - **Brahms: Workpractice modeling, Agents, and VE**
  - **Trends and Opportunities for Exploration Systems**





# Guidon: Case Method Tutor (1979)

---



**Student: What is the CSF Glucose?**

**Guidon: The CSF glucose value is 5.**

**We have substantially completed our discussion of the type of the infection. Would you like to make a hypothesis now?**

**S: Yes**

**G: What is the type of the infection?**

**S: Bacterial (.9)**

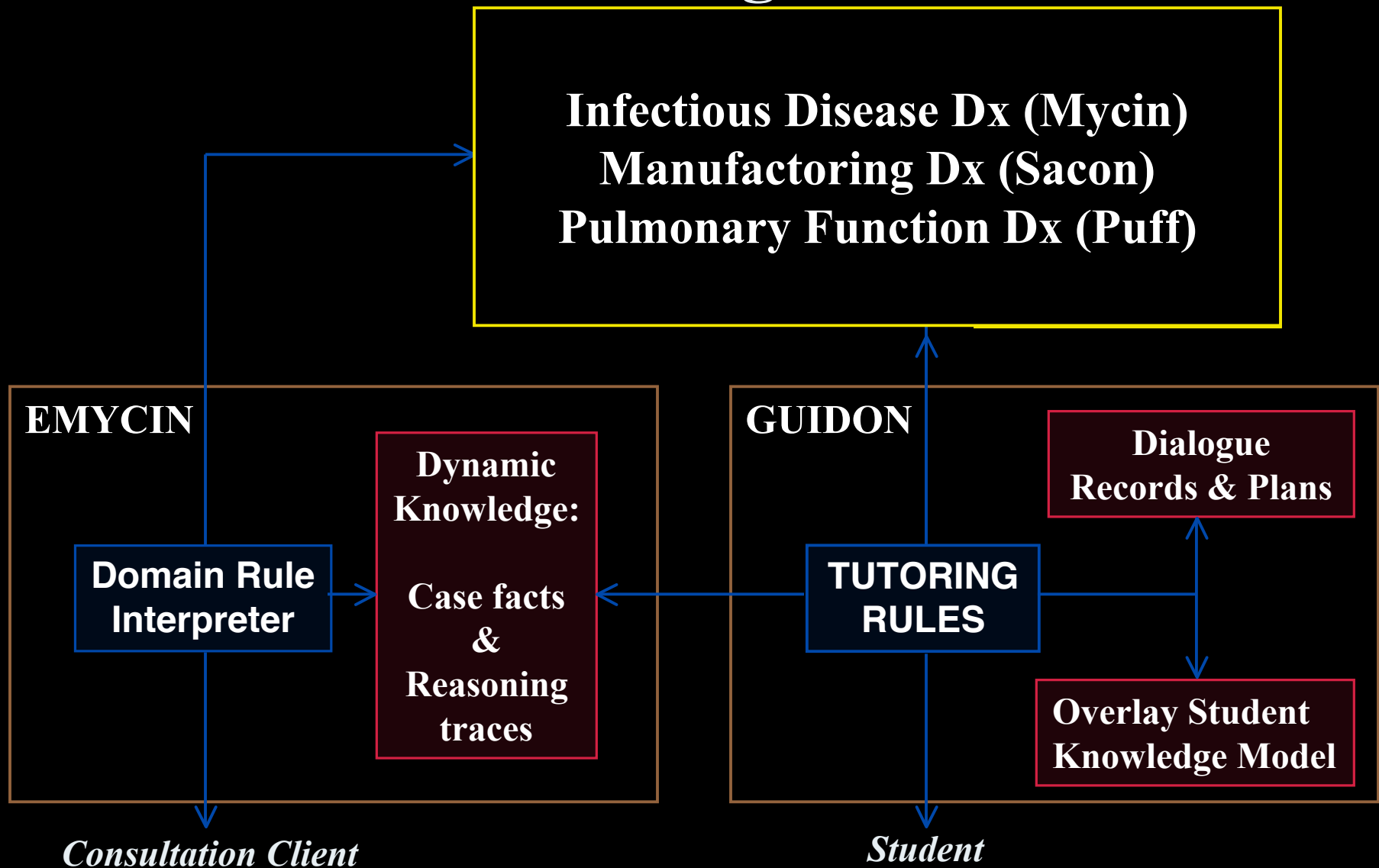
**G: What facts about this case tell you that the type of the infection is bacterial (.9)?**

**S: CSFGLUC, PMNS, CSFPOLY, PROTEIN**

**G: The percent of PMN's in the CBC is not relevant for determining the type of the infection.**

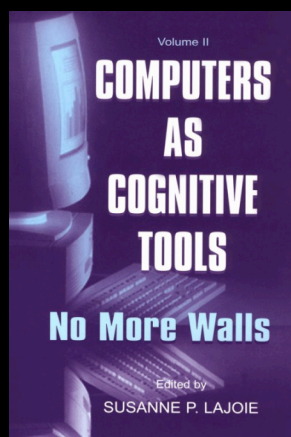
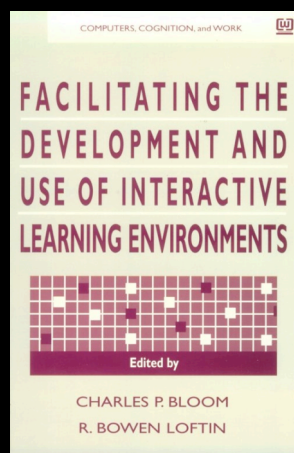
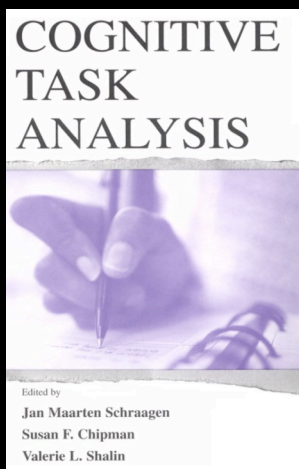
**You're right about the CSF protein, the percent of PMNSs in the CSF and the CSF glucose value, however you should have mentioned the fact that the meningitis is partially treated (.95), the WBC from the CSF and the fact that the simultaneous blood glucose value is not known.**

# Guidon's Domain-General Design



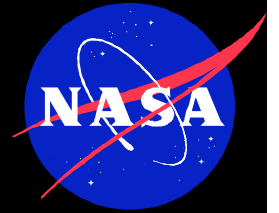


# ITS Successes (30 Years)



- High School Algebra
- Electro-mechanical Troubleshooting (military)
- Manufacturing Process Control
- Computer Programming
- Medical Diagnosis

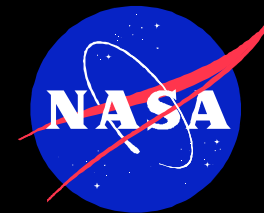
# Astronauts as Students



- Multiple PhDs/MD
- Insufficient time from specs to flight to formalize domain knowledge
- Highly procedural, mission critical, manipulative skills
- “Practicing understanding”
- Tasks open to alternatives
- CBT with personal tutors
- Comprehensive ground support “coach in your ear”



# Varieties of Simulation Training



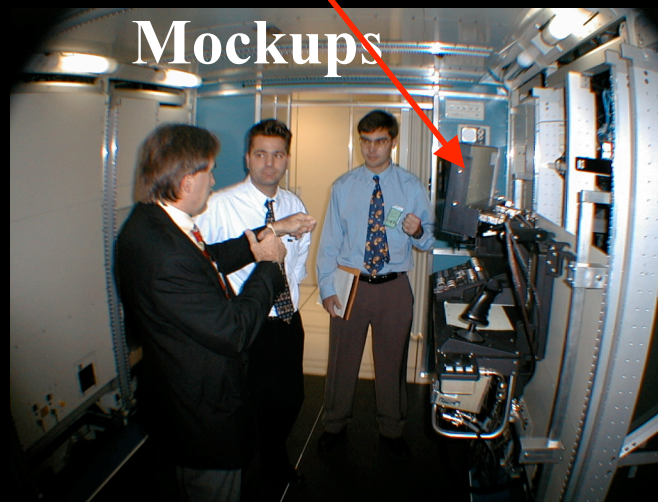
“Integrated”



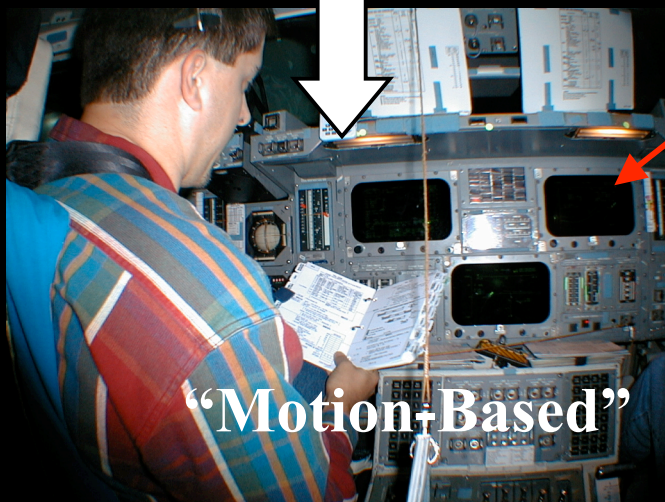
“ICAT”



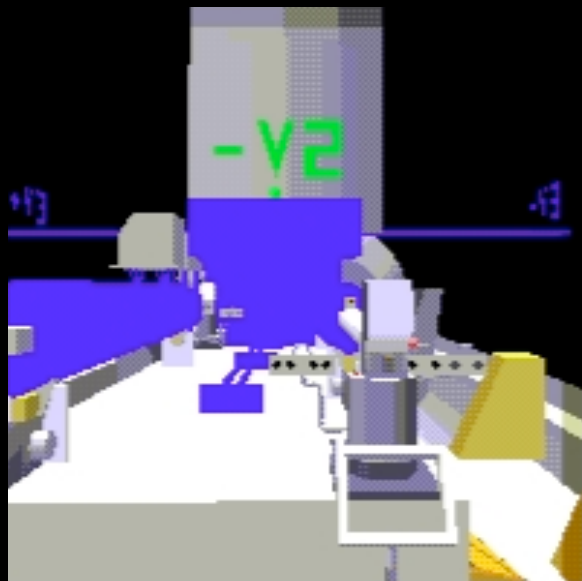
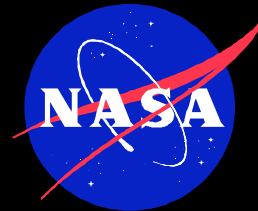
Mockups



“Motion-Based”



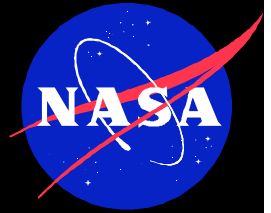
# Bowen Loftin's Hubble VE



- Dec '93 Hubble Repair Mission
- Hubble model + Shuttle payload bay
- 100 team members, 200 hrs training
- Feature id & repair constraints; six EVA scenarios (part changes)
- Procedure monitoring, intervention, & assistance



# Shalin's ICAT Evaluation



- Part-Task model highly restricted
  - Flattens data-process relation (e.g., comparing alternative methods)
  - Omits contextual information (e.g., orbit #)
  - Omits interaction with other individuals/subtasks
- Increased cognitive demand
  - Undermined learning
  - Misleading evaluation of effectiveness
- Need richer work system conceptualization

S: ... I would tell dynamics to make ephemeris 2 and 4 look like 1.

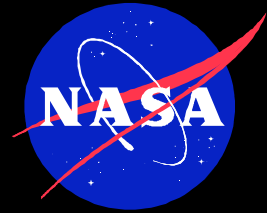
E: How would you do that?

S: I would tell them exactly that – to make ephemeris 2 and 4 look like 1. So, I'm going to have to do this myself.

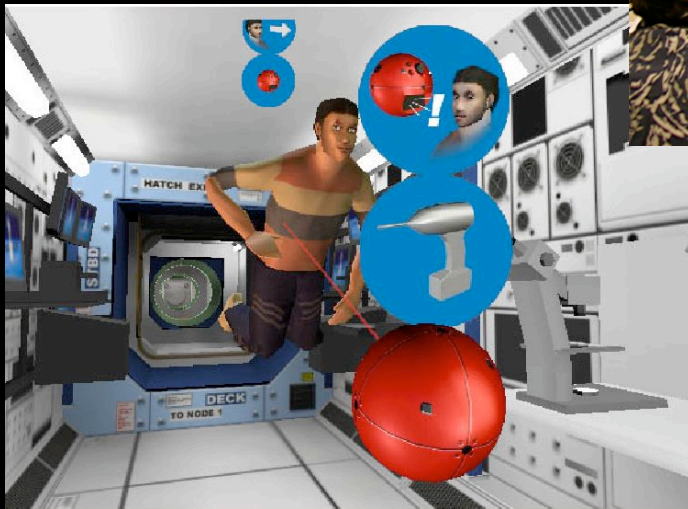




# Technology Foundations for Revitalizing ITS at NASA



## *MER Work System Study & Simulation*



## *BrahmsVE Human-Robotic Systems*

## *Mobile Agents*

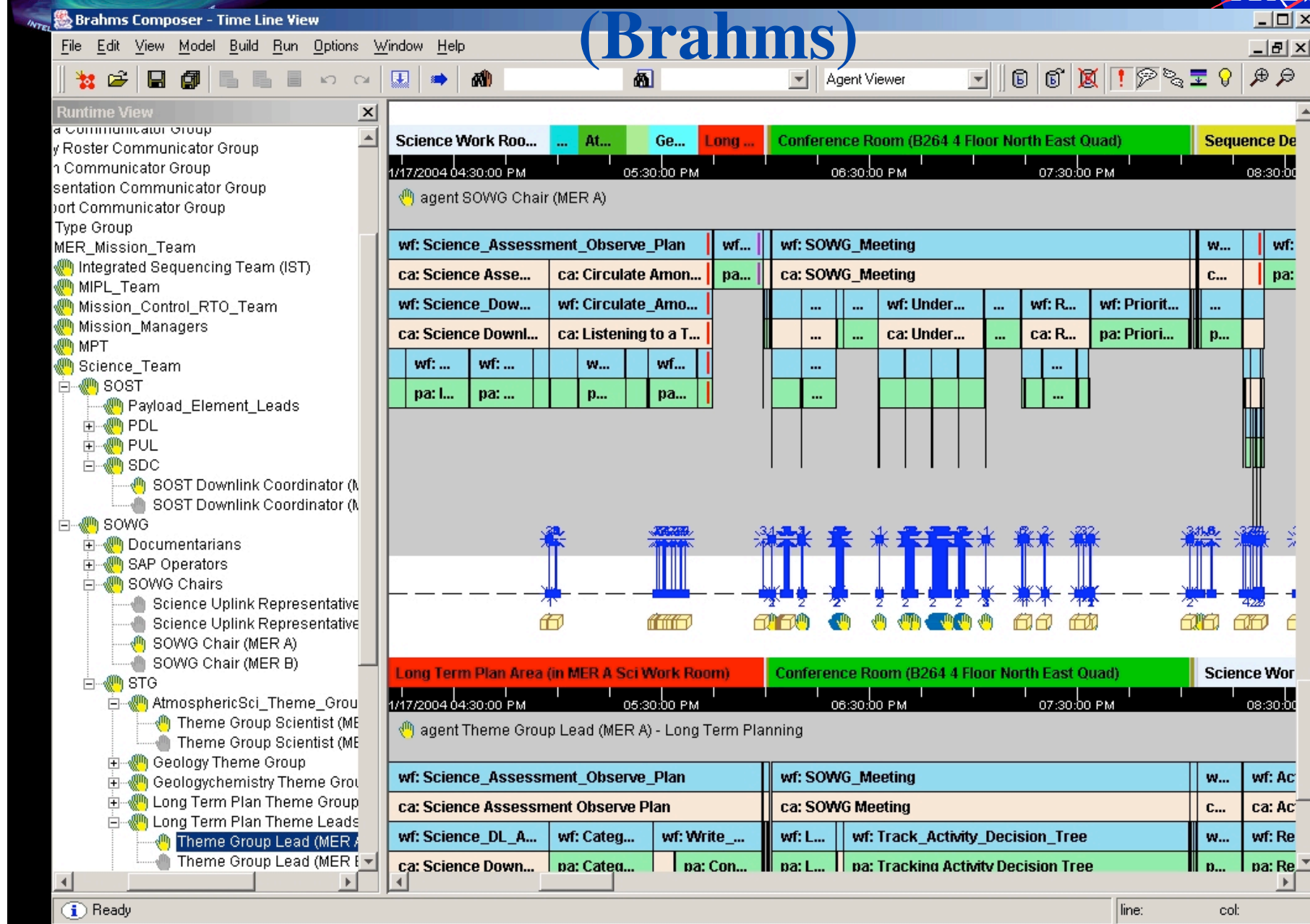


- Work practice (activity-based) simulation of mission operations and tools
- Virtual environments for design and training of human-robotic systems
- Multiagent systems using NL for life support and surface exploration

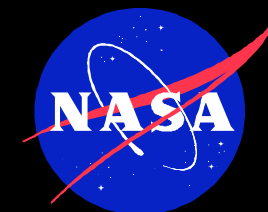
# MER Operations Simulation



(Brahms)



# ISS Assembly Training



00:00:00 - CMG changeout procedure for STS-114 - Cam1

Camera: 1 2 3

☒ Automatic Camera

**SimCMGChangeOut**

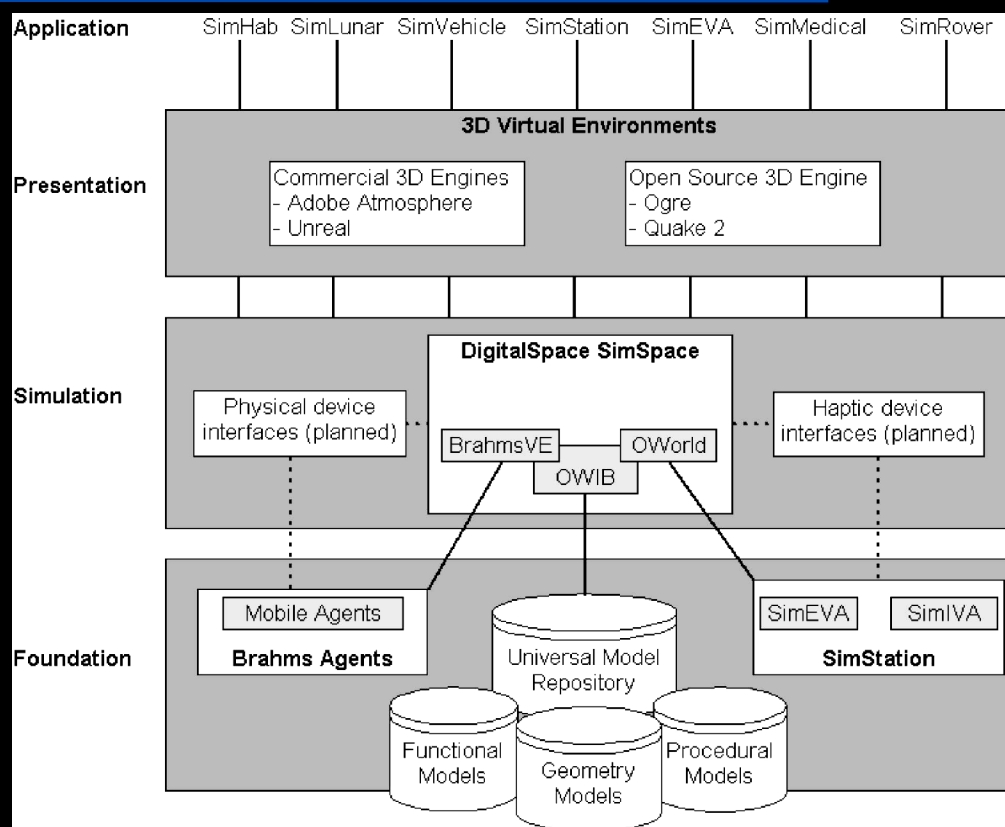
Start Stop

1. **Prepare Ballstacks**
2. Position old CMG on Ballstack
3. Attach old CMG to Ballstack
4. Prepare to approach LMC
5. Approach LMC
6. Detach CMG from LMC
7. Prepare to remove CMG from LMC
8. Remove CMG from LMC
9. Position new CMG on Ballstack
10. Attach new CMG to Ballstack
11. Move to old CMG
12. Detach old CMG from Ballstack
13. Prepare to approach LMC with old CMG

Cam1 - CMG changeout procedure for STS-114 - 00:00:00

# BrahmsVE Architecture

- **Multiagent Work Practice Simulation:**  
People, systems, places, activities, communications
- Coupled to animation graphics in virtual world
- **Browser-based Visualization**  
implemented in *Adobe Atmosphere*
- Foundation for interactive distributed training



***Agent system simulates behaviors;  
Virtual World simulates spatial relations***



# MOBILE AGENTS: “Automating Capcom”

Robot on ledge tracks  
Astronauts & takes photos  
when commanded

Astros can work in  
parallel, talking to  
personal agents

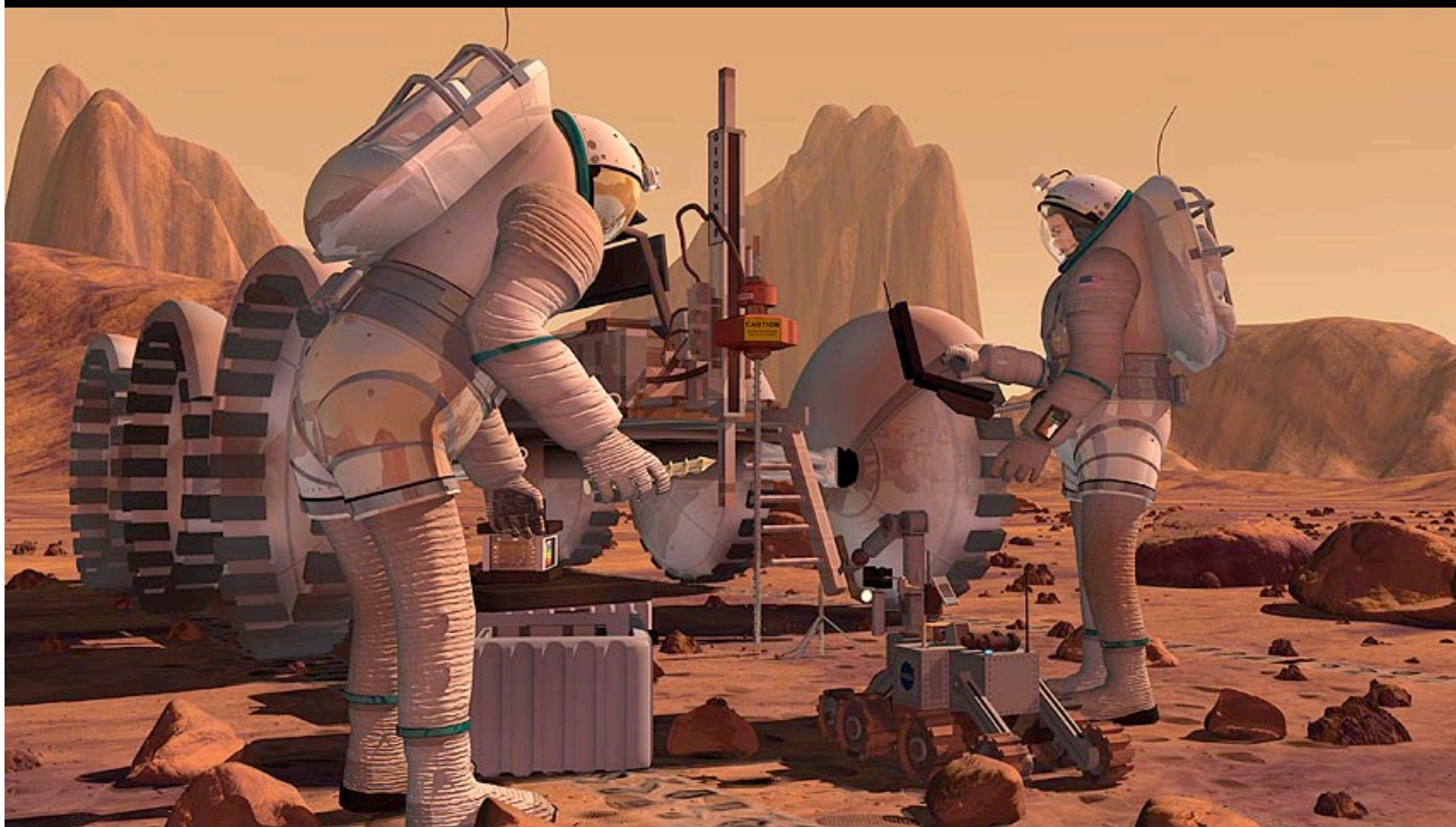
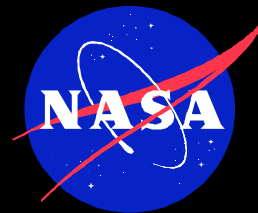


Voice annotation is recorded  
and transmitted to database  
in habitat & to RST on earth

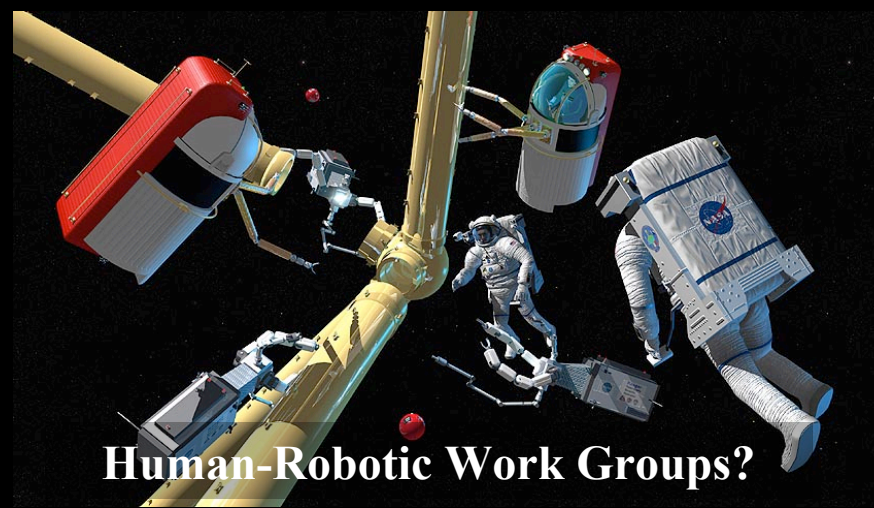
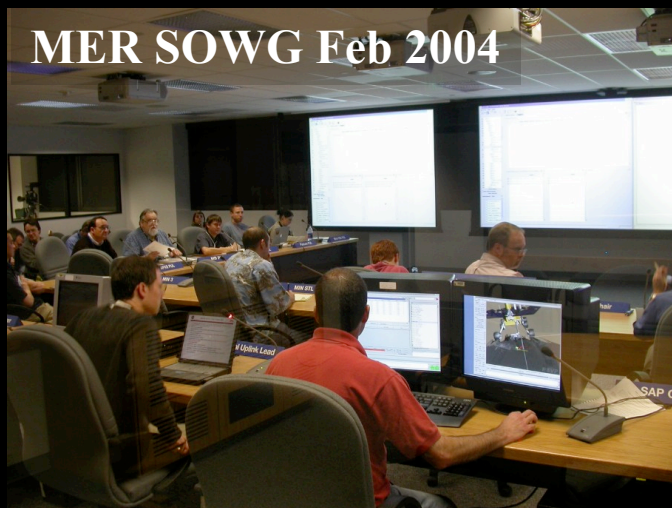
Robot in “follow me” mode



# Recommendations



# A Key Point



Scientific understanding of the *differences* between present technology and people is essential for both exploiting and improving computational tools

*What is Collaboration? Teamwork? Decision making?*



# For more information...

- <http://bill.clancey.name>
  - Simulating Activities
  - Field Science Ethnography
  - Automating CapCom
  - Roles for Agent Assistants in Field Science
  - Multiagent Modeling and Simulation in Human-robotic Mission Operations Work Systems Design (Sierhuis, et al.)
  - Agent-based Modeling of Collaboration and Work Practices Onboard the ISS (Acquisiti, et al.)
- [www.agentisolutions.com](http://www.agentisolutions.com)
  - Brahms download & refs



*Robotic tool (left); Scientist (right)*